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Application Of Electrical Resistivity And Hydrochemical Methods To Investigate Agricultural Pollution In Some Parts Of Ojo, Lagos, Southwest, Nigeria

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Abstract:

The environmental implication of agricultural activities in Oko-efo area in Ojo Local Government Area of Lagos State on groundwater has been carried out using geophysical and hydrochemical methods. The geophysical method involves vertical electrical sounding while the hydrochemical analyses, using standard analytical methods were carried out on the groundwater samples from both hand dug wells and bore holes in the area. Two hundred meters (200m) away, four vertical electrical soundings were also carried out within the study area to serve as control. The geophysical layers were delineated from interpretation of vertical electric sounding data and the polluted region showed resistivity value between 32-38 Ωm. The variation of Mg, Zn and Fe in both shallow wells and borehole water within the area support the evidence of pollution from Agricultural practices as well as the vertical electrical sounding data got at 200m away.

Keywords: *Vertical electrical sounding, hydorchemical analysis, shallow wells, Oko- Efo.*

Introduction

Water is generally accepted as one of the vital elements of life and many body functions depend on it. Regrettably, water of adequate quality and quantity is in short supply. (Ayolabi, 2005). Groundwater is generally understood to mean water that occupies the void of rocks in the upper earth crust irrespective of the type, origin and age of the rock. It is also called underground or subsurface water. Usable quantities can only be tapped in sand, gravel and rock formation that have sufficient void space to hold and conduct water. The water stored in these open spaces within underground rocks and unconsolidated material, have become increasingly important as the demand for freshwater by agriculture, industry and domestic uses has reached an all-time high demand. Understanding quality status of groundwater is as important as to its quantity, for it helps in determining the suitability of water for various purposes. Variation of groundwater quality in any area is a function of physicochemical quality parameters which are greatly influenced by geological formations and anthropogenic activities of the area (Majolagbe et al., 2011). Various major sourcesof pollution in groundwater include leachate from municipal refuse dumpsite, industrial discharge (liquid waste), domestic waste, salt water intrusion, application of agricultural chemicals, Oil spillage and pipeline vandalisation and geological formations. These sources generate pollutants ranging from heavy metals, N-species, Chlorinated hydrocarbon, phenols, cyanides, pesticides, inorganic species and bacteria (Yusuf, 2007). It is well known that agriculture is the single largest user of freshwater resources, using a global average of 70% of all surface water supplies. Except for water lost through evapotranspiration, agricultural water is recycled back to surface water and/or groundwater. One of the serious agricultural relation sources of water pollution to sedimentation are pesticides and decomposed organic materials. Nitrate forms when microorganisms break down fertilizers, decaying plants, manures, or other organic materials. Plants take up the nitrate, but sometimes rain or irrigation water can leach them directly into groundwater (Kit et. Al.2010). The increasing use of pesticides in raising agricultural production has resulted in an incipient degradation of groundwater quality in area where such is practice (Karanth 1987). Groundwater had depleted in quality in many areas and these are caused by problems such as pollution from agricultural activities, landfills and toxic waste which have rendered the groundwater supply unsafe. The levels of trace metals and nitrate increase with the intensive use of pesticide and fertilizer. Nitrate contamination of ground water depends upon climate, fertilizer or manure management, soil, crop, and farming systems. Soil thickness and distance between the root zone and groundwater also determine the vulnerability of an aquifer to pollution. The health consequences of trace metals particularly at elevated level in water is adequately reported in literatures (Oniawa et al 1999, Odukoya et al 2000, Majolagbe and Bamgbose, 2007)), while high level of nitrate in Drinking water has been linked to stomach cancer and negative reproductive outcomes in humans, and to lower productivity in livestock. Human gastric enzymes play vital role in the health implication of high level of NO_3^-, by reducing naturally, nitrate to nitrites. This, in the view of Boumediene et al., (2004) is a serious disturbance of the system exchange: blood-oxygen the methemoglobinemy, a blue baby syndrome, and in the long run, to the formation of nitrosamines, which can supposedly produce carcinogenic cells in adults. It also causes gastric carcinomas. Nitrate is highly soluble, and therefore very susceptible to leaching to groundwater.The study focuses on delineating the extent of agricultural pollution on the ground water using electrical resistivity method. The hydrochemical and microbiological analysis were also carried out on water samples from well and borehole in the enviroment.

Location of Study Area

Oko-efo agricultural area is located along Lagos State University-Igando road in Ojo local government of Lagos state (Figure 1). Ojo is located between latitude $4^0 15'$ and $4^0 17'$ north and on longitude $12^0 55'$ and $13^0 00'$ east. Oko-efo is an open vast land for agricultural purposes. It stretches from Iba road junction near Ojo/Lasu to Lagos badagry expressway to Agboroko area, it spans about 5 kilometer.The study area is bound on one side by Lagos State University (LASU) and on the other side by Nigeria Army Post Service Scheme. The relief features of the area is the low lying nature of the terrain, more than half of the entire local goverment has an elevation of between 3m and 6meters high above sea level (Odewunmi, 1995).

It was also identified that the soil is composed of bedrock which is mostly sedimentary and mainly of alluvial deposits while the soil are loose, light grey sand mixed variously with varying proportion of vegetable matter on the lowland while the reddish and brown loamy soils axist in the upland. The porosity of the soil is very high (Balogun et al, 1997).

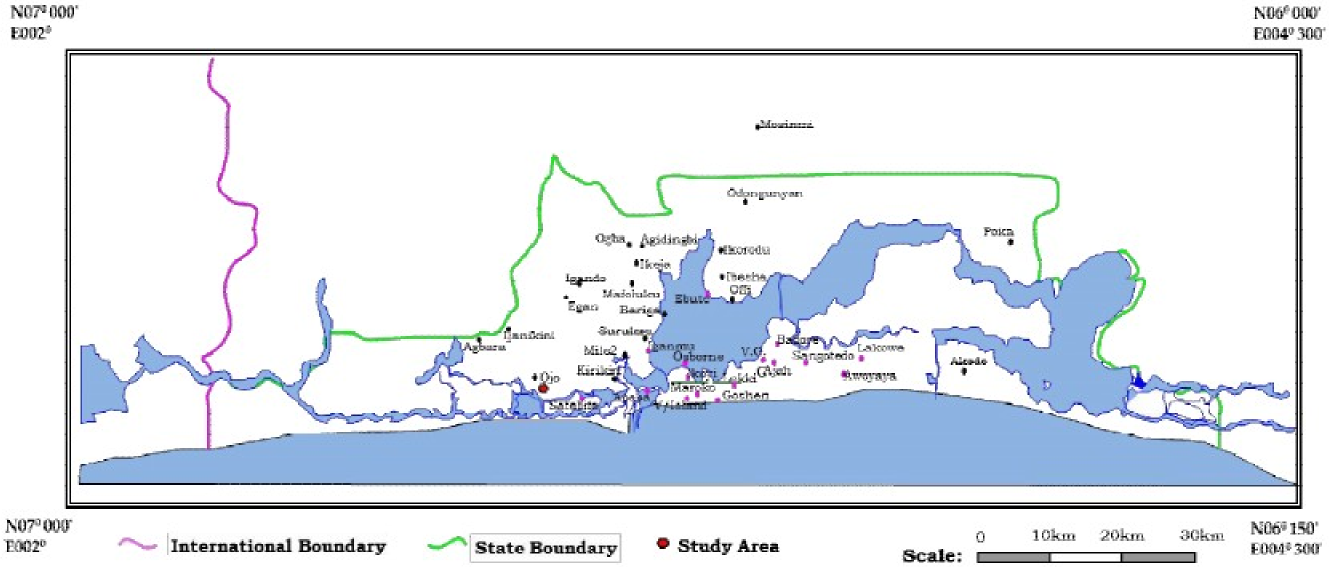


Figure 1: Map of Lagos State Showing Study Area

Data Acquisition

A total of ten (10) vertical electrical soundings (VES) using Schlumberger array with maximum current electrode seperation (AB/2) which varied between 1 and 150m along transverse AA′ and BB′ (fig 2) were carried out. ABEM Terrameter SAS 1000 was used in obtaining ground apparent resistivity at each VES station. The acquired data were modeled with the aid of computer iteration known as WINGLINK. Samples of these curves are shown in figure 3a and 3b.

The layer thickness and resisitivity values obtained from the computer iteration show a high confidence on error values and these were later used for further interpretations.

Hydrochemistry

Groundwater samples were collected from twenty (20) active wells and bore holes across the study area. Samples were drawn with the aid of locally made plastic drawer into two different types of polyethylene bottles: 1.5L for physico- chemical parameters and 0.75L plastic bottle for metal analyses (APHA, 1998) The plastics were previous washed and soaked overnight with 5 % HNO_3 solution (Protano,2005). A 0.75L of the sample was acidified with 1.5ml concentrated HNO_3 (Analar), after which samples were transported to laboratory and kept at 4°c prior the time of analyses. Blanks were treated just as the samples.

The electrical conductivity (EC), pH and temperature of the groundwater samples were determined in-situ. The EC was carried out electronically, pH by pH meter (pHep HANNA HI 98107) and temperature was estimated using thermometer. Determination of alkalinity and acidity were done titrimetrically (APHA, 1998)],Total Hardness by complexomertry (APHA, 1998) ,Total suspended solids, dissolved solids and total solids by gravimetry (APHA, 1998) and (DOE,1972),Chloride by Mohr's method [(APHA, 1998), Sulphate by turbidimetric method (APHA, 1998),Phosphate by colorimetric and nitrate by Phenol disulphunic acid method . Determination of metals: Cu, Mg, Zn, Pb and total Fe were carried out, employing Flame Atomic Absorption Spectrophotometry.((Buck scientific 210VGP model). (APHA, 1998; ASTM,1982;USEPA,1983).

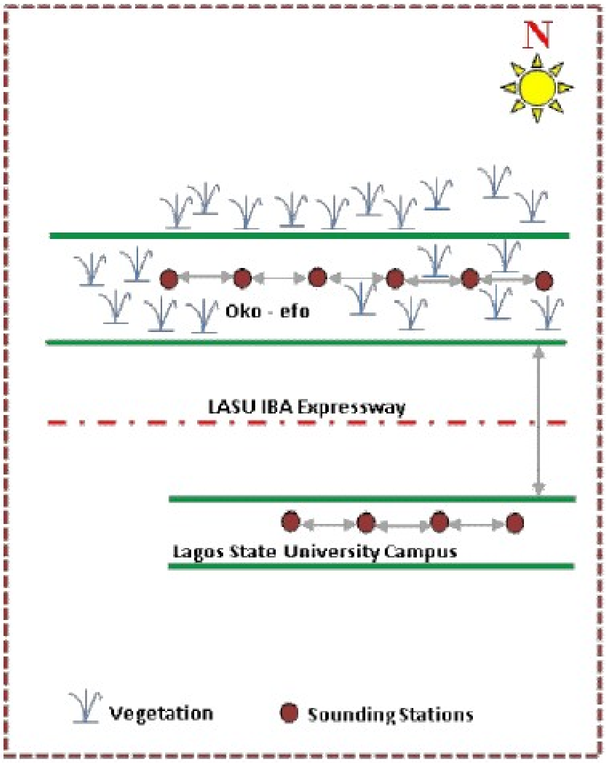


Figure 2: Site Map of Study Area

Results And Discussion:

The results of apparent resistivity obtained at each VES station were plotted against the electrode spacing (AB/2) for each VES. The resistivity curve types AHA, HA, AKA and QKA were obtained and some of these are shown in fig 3(a & b). The results of the interpreted VES data are presented in table 1.0. The study area was divided into two (2) categories, which are AA' and

BB'. The AA' shows the geoelectric section of six (6) VES and BB' has four (4) VES which were obtained at about 200m away to serve as a control. The results of the hydrochemical analysis of the water sample from well and borehole are summarize in Table 2.

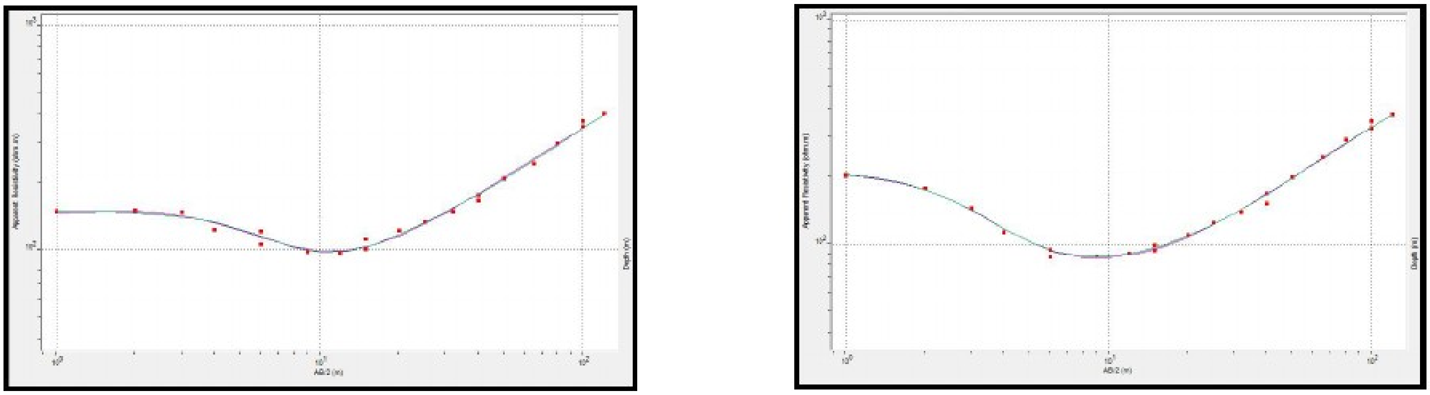


Figure 3a: Vertical Electrical Sounding Plots at Oko-efo

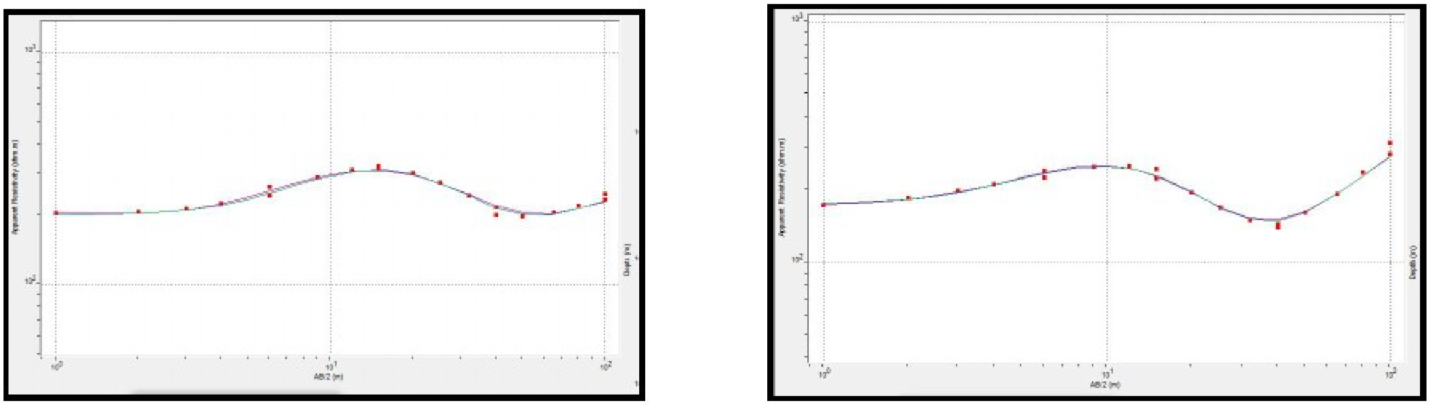


Figure 3b: Vertical Electrical Sounding Plots at 200m away

VES No	ρ_1	ρ_2	ρ_3	ρ_4	D_1	D_2	D_3
1	106.19	59.91	82.07	281.48	2.70	6.89	10.4
2	211.18	73.31	122.89	993.23	1.43	7.74	22.39
3	150.28	54.85	203.05	1510.73	3.23	7.82	33.75
4	155.21	80.43	150.49	-	3.38	10.58	-
5	156.04	53.19	113.87	1274.01	3.99	8.3	23.5
6	80.28	32.22	312.26	-	1.68	4.45	-
7	173.71	407.75	61.63	1682.8	1.43	10.41	32.88
8	176.03	355.78	39.89	1088.34	2.32	9.4	19.56
9	199.21	548.65	90.95	353.22	3.63	10.8	27.70
10	209.24	101.35	265.48	3017.66	1.12	2.45	21.75

Table 1. True Resistivity and Horizon Depths

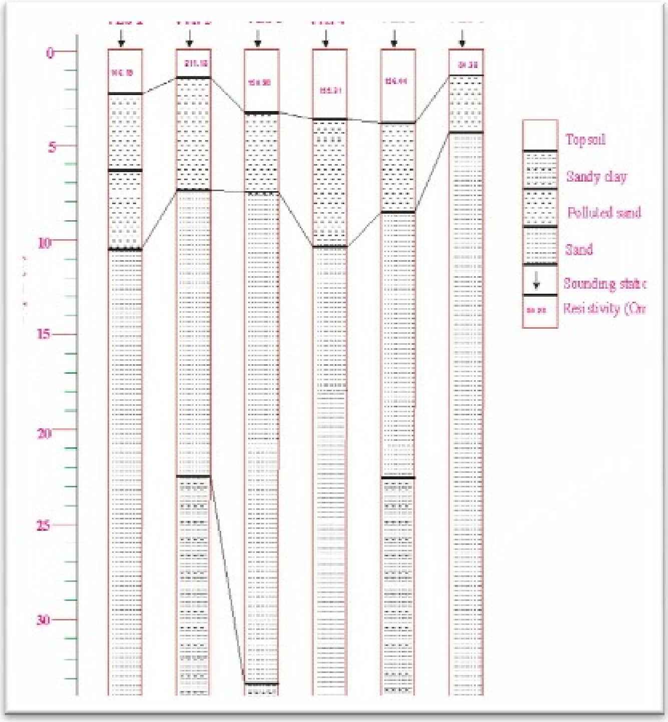
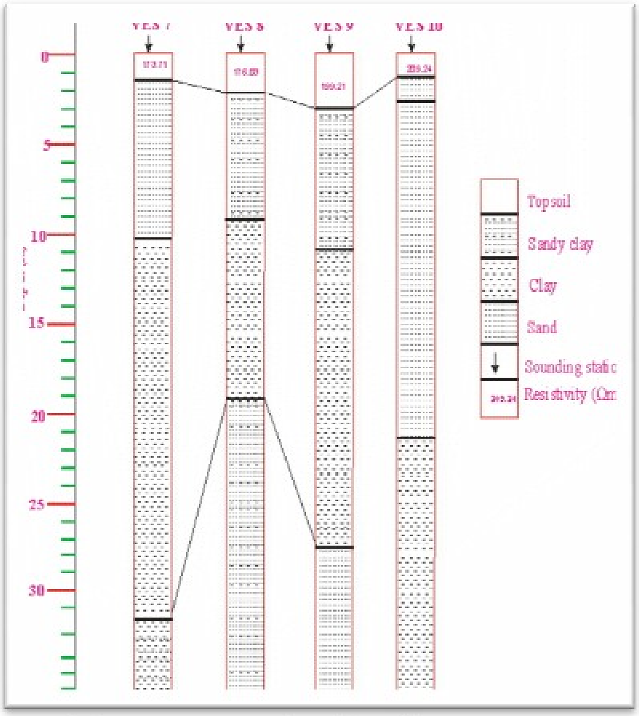


Figure 4: Geoelectric Section AA'



ρ = True resistivity, D = Depth

Figure 5: Geoelectric Section BB'

Geoelectric Section AA'

This section consists of VES 1- 6. A total of four geo- electric layers were obtained from this section. The first geoelectric layer had thickness in the range of 0.5 to 3.99m and resistivity 80.28 to 211.18Ωm. The layer was the topsoil with mixture of sand, decomposed organic and inorganic materials. The second geoelectric layer was representative of polluted zone with low resistivity of 32.22 to 80.43Ωm and thickness 0.6-14m.The third layer under VES 1 also denoted polluted zone. Its resistivity was 82.07Ωm and thickness 5m while in the same layer VES 2 – 6 constitutes a probably sand formation with resistivity in the range of 114 - 312Ωm and thickness 5 to 10.2m. Resisitivity of the fourth layer in VES 2, 3 and 5 ranges from 995 to 1510Ωm. The region represents a good aquiferous zone when compare with the borehole information avaliabe at the time of the study. The thickness of this geoelectric layer cannot be determined as the current electrode terminated at the zone.

Geoelectric Section BB'

This section comprises VES 7- 10 which was obtained about 200m away where no agricultural activities had taken place before and this was done with a view to serve as control. A total of four geoelectric layer were delineated along this traverse. The first geoelectric layer, topsoil, has resistivity range 174 to 209Ωm with thickness 0.9 to 1.3m which is compose of mixture of sand, clay and other relief materials. The second layer is composed of probable sand formation with resistivity value of 101.5 to 548.65Ωm and thickness of 2.45 to 10.41m. The third layer of VES 7-9 had resistivity range 39.89 to 90Ωm. The layer has a signature of clay formation. The forth layer has resistivity of 353.22 to 3017.66Ωm, this composed of clayey sand, except in VES 9 which depicted a sand formation though the thickness of the layer cannot be determined as the current electrode terminates at that layer.Correlation of the two-geoelectric section show that the first geoelectric layer constitute the topsoil and consisted of mixture sand, decomposed organic and inorganic materials. The second geoelectric layer composed of probable sand formation but the low resisitivities values 32-80 Ωm obtained from figure 5 might due to the fact that the layer had been polluted by the fertilizer/chemicals used on the farmland. The study could affirm that it was easy for the pollutant to have migrated owing to the fact that the layer was composed of sand. The resistivity value for this layer at geoelectric section BB^1 was between 101.5-548.65

Ωm. The acquired values show that this area was polluted. The result further confirmed that the suspected pollutant might be that of agricultural chemicals

Hydrochemical Analysis

The physicochemical results of the groundwater samples analysed are shown in Table 2.0., the concentration of metals is presented in Table 3.0while the concentration of anion in Table 4.0

The groundwater samples analysed are classified shallow wells, Deep well and Bore hole water based on depth of water. The observed pH values decrease with increase in depth, a reflection of salt impact possibly from fertilizer application. The pH values of all water sample investigated are in acidic region. This may be as a result of population and industrialization, the growing features of Lagos state. The high level of CO_2 produced could lead to acid rain, which percolate the soil surface and subsequently contaminate the aquifer.

The total hardness also decreases with increase in depth. The observation is further validated by the concentration of magnesium, one of the cations responsible for hardness of water. Magnesium is probably sourced from the application of chemical and fertilizer. This point at the environmental impact of agricultural practices on groundwater quality. Agricultural practice remain the non- point source pollution in groundwater. The application of fertilizer and the use of surface irrigation, a common practice in the study area enrich the groundwater with salts, and nutrients especially nitrate (WHO, 1993).

All metals investigated were found present in groundwater samples analyzed except Pb which is absent in both deep wells and bore holes. The level of metals observed in the present study was found to be within the safe limits. However, the concentration of element Iron was far above the WHO allowable limit of 0.3mg/L iron. This probably illustrates that the deeper the well the safer it is from pollution from agricultural activities. The elevated level of iron could be from atmospheric deposition which has been described as a major source nutrient, metals and organic contaminants in the soil and subsequently the groundwater. Geological formations of an area could be the additional source of iron. Geo-hydrological condition of the basin and its pH are among other factors that influence the solubility of Iron (Majolagbe et al., 2012). Iron is though considered as an essential element; it becomes toxic, when present at very high concentration and could induce siderosis in spleen, malfunction of liver and initiate diabetes mellatius (Klassen et al., 1986). The concentration of anions investigated (Table 4.0) show that all anions analyzed were found below the WHO maximum limit. The increase in level of chloride from in the order of shallow well < deep well < bore hole portray, that there might be other source(s) of Chloride. Nitrate level in groundwater samples analyzed is in increasing order of bore hole < deep well < shallow well. The sources of nitrate in groundwater include discharge of municipal wastewater and sludge septic system, leachates from dump sites and run off from agricultural areas where there is intensive use of chemicals and organic substance, percolation of leachates from farm where fertilizers and manure has been under intensive use and N-fixation from atmosphere by legumes, bacteria and lightning (Kit et. al., 2010). The average concentration of nitrate in shallow well is 13.74mg/L, though lower than the WHO maximum limit of 45mg/L nitrate in drinking water, but indicate possibility of nitrate pollution in not too far future , if continuous use of manure and other chemicals is not controlled. The presence of elevated levels of nitrates particularly in drinking water is a threat to man (Majolagbe et al., 2011). Toxicity of nitrate comes from the natural reduction to nitrites by gastric enzymes in human system. Nitrates present in great quantities in drinking water can cause serious illnesses for the consumer, particularly methemoglobinemy in children, nursing infants and nitrosamine in adults. Nitrite is absorbed in the blood, causing conversion of hemoglobin (the oxygen-carrying component of blood) a to methemoglobin, a condition in which oxygen is not efficiently transported. Severe methemoglobinemia can result in brain damage and death (Self and Waskom, 2011).

S/N	Parameters	Shallow wells			Deep wells			Boreholes			WHO
		Range	Mean± (S.D)	SEM	Range	Mean± (S.D)	SEM	Range	Mean± (S.D)	SEM	
1	Depth (m)	0.48 – 81	0.64±13.29	16.61	1.91 – 3.79	3.01.5±17.95	10.37	--	--	--	--
3	pH	6.30 – 7.50	6.88±0.43	0.16	6.30 – 7.20	6.65±0.35	0.18	5.50 -6.90	6.05±0.52	0.26	6.50 – 8.51
4	Temperature ($^{\circ}$C)	28 – 29	28.50±0.50	0.09	28 .00–29.00	28.50±0.50	0.09	30.00 – 32.00	27.5±1.12	0.56	--
5	TDS (mg/L)	20.00–187.00	98.75±62.92	6.33	74.00 – 230 .40	152.25±60.31	4.95	34.43 – 259	149.50±107.18	8.75	500 – 1500
6	Total Alkalinity (mg/L)	2.10–48.00	13.50 ± 19.92	5.39	2.00 – 30.00	9.50 ± 11.86	3.76	2.00 – 4.80	2.00± 1.00	0.71	30 – 200
7	Acidity (mg/L)	1.80 – 3.60	2.43±0.70	0.45	1.25 – 1.70	1.44±0.17	0.14	0.75 – 3.45	1.78±1.00	0.74	No guideline
8	Total hardness (mg/L)	48.00 – 217.00	135.67± 65.10	5.61	46.00 – 120.00	80.25 ± 32.71	3.65	4.03 – 126.40	54.75 ± 45.50	6.08	500
9	Electrical Conductivity (µS/cm)	33.33 – 311.67	164.59±104.80	8.18	123.33 – 383.33	253.75±100.52	6.31	56.67 – 431.67	249.17±178.64	11.32	1400
10	TSS (mg/L)	43.48 - 205.70	113.88± 62.92	5.89	81.40 - 252.90	167.43± 66.32	5.12	37.40 - 284.00	164.10± 117.60	9.18	--

Table 2.0: Descriptive Characteristics of the Physicochemical Parameters

	Parameters	Shallow Wells			Deep wells			Bore holes			WHO
		RANGE	**Mean± (S.D)**	**SEM**	**RANGE**	**Mean± (S.D)**	**SEM**	**RANGE**	**Mean± (S.D)**	**SEM**	
1	Copper (Cu) (mg/L)	0.031 – 0.172	0.078±0.05	0.57	0.04 – 0.175	0.098±0.05	0.025	0.031 – 0.065	0.045±0.02	0.09	1.3
2	Zinc (Zn) (mg/L)	0.073 – 0.145	0.096±0.02	0.06	0.018 – 0.502	0.28±0.20	0.100	0.062 – 1.434	0.46±0.56	0. 83	5.0
3	Magnesium (Mg) (mg/L)	1.830 – 13.39	6.31±4.42	1.76	1.13 – 2.140	1.86±0.42	0.210	0.90 – 2.57	1.76±0.71	0.52	
4	Iron (Fe) (mg/L)	0.200 – 5.340	2.79±1.82	1.08	0.21 – 0.300	0.24±0.04	0.019	0.11 – 0.29	0.23±0.07	0.14	0.30
5	Lead (Pb) (mg/L)	0.00 – 1.10	0.280±0.48	0.92	ND	ND	ND	ND	ND	ND	0.01

Table 3.0: Concentration of Metals of groundwater samples from both study areas

	Parameters	**Shallow wells**				**Deep wells**				**Bore holes**				**WHO**
		Range	**Mean**	**SD**	**Sem**	**Range**	**Mean**	**SD**	**Sem**	**Range**	**Mean**	**SD**	**Sem**	
1	Chloride (mg/L)	9.99 - 29.99	16.37	8.10	1.99	6.99 - 22.50	18.00	6.40	1.50	15.5 - 36.99	24.9	9.4	1.88	250
2	Sulphate (mg/L)	0.023-0.068	0.038	0.019	0.09	0.030-0.068	0.025	0.025	0.15	0.026 - 0.064	0.05	0.01	0.06	400
3	Phosphate (mg/L)	0.009 - 0.011	0.010	0.001	0.01	0.008-0.009	0.009	0.001	0.01	0.008 - 0.010	0.0086	0.02	0.22	No guideline
4	Nitrate (mg/L)	10.86-16.03	13.74	2.09	0.56	1.69- 5.27	3.29	1.01	0.56	0.59 - 1.18	1.08	0.03	0.02	45

Table 4.0: Concentration of Anions of groundwater samples from both study areas

Conclusion

The importance of agriculture cannot be neglected especially in a growing economy but study carried out in Oko-efo agricultural area in Ojo Local Government, Ojo, Lagos shows that agricultural activities; fertilizers, herbicides and pesticides applied have infiltrated the subsurface soil and subsequently contaminate the groundwater beneath. The impact of these chemicals on the groundwater has been investigated using geophysical and hydro chemical analysis. The data generated from this study can infer that water quality in the area up to depth of 0.64m (shallow well) are affected and rendered unwholesome. The nitrate levels in shallow well points are possible nitrate pollution in near future. The tendency for further migration of pollutant due to the nature of the soils in the study area is high. Hence, the need for the appropriate agencies of Lagos state government to undertake urgent measures to protect the aquifer in the area.

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